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ABSTRACT

In two different studies the relationships between study time patterns, retrieval time patterns, and clustering were examined. In the first study middle Socioeconomic Status white students in grades 2 through 5 increased their use of the clustering strategy as a function of the organizational nature of the list. List composition facilitated clustering among older children more than younger children. No relationship between study time patterns and clustering was observed. In the second study, the same clustering performance was observed among low Socioeconomic Status black and white students in grades 2 through 5. A relationship was observed, however, between retrieval time patterns and clustering. Clustered items were associated with shorter inter-item intervals than non-clustered items. This was observed regardless of children's age, background, or list composition. (Author/MV)

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DEVELOPMENTAL STUDIES OF THE TEMPORAL PROPERTIES OF CLUSTERING

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Abstract

In two different studies the relationships between study time patterns, retrieval time patterns, and clustering were examined. In the first study middle SES white students in Grades 2 through 5 increased their use of the clustering strategy as a function of the organizational nature of the list. List composition facilitated clustering among older children more than younger children. No relationship between study time patterns and clustering was observed. In the second study, the same clustering performance was observed among low SES black and white students in Grades 2 through 5. A relationship was observed, however, between retrieval time patterns and clustering. Clustered items were associated with shorter inter-item intervals than non-clustered items. This was observed regardless of children's age, background, or list composition.

DEVELOPMENTAL STUDIES OF THE TEMPORAL PROPERTIES OF CLUSTERING

The investigation of the development of learning through verbal mediation traditionally has involved a free recall learning paradigm. Typically, subjects are presented with a list of information in which are embedded categorical groupings of conceptually related items. By studying the amount and patterns of items recalled under differing experimental conditions, assumptions are made about the cognitive processes involved. When recall patterns reveal a reorganization of the items, that is, conceptually related items are recalled contiguously, it is assumed that subjects have recognized the categorical structure of the list and used the superordinate categories as conceptual pegs (Jensen, 1971) to structure the learning of the list. Such a restructuring by clustering the items which are conceptually related presumably results in more efficient learning and greater recall.

The study of clustering has evoked many scoring procedures which are said to provide an index of the use of this strategy in the free recall of stimulus lists. Interpretation of the meaning of these measures depends upon the degree to which inferences of organizational processes can be made from the person's recall. Belmont and Butterfield (1969) among others, have argued that inferring cognitive strategies from recall data is imprecise and ambiguous. In their short-term memory research, they measured study time in a self-

paced procedure, and inferred the use of organizational strategies such as active and passive rehearsal from the temporal data rather than indirectly from the recall data.

Recent evidence suggests support for the utility of temporal data to indicate use of the clustering strategy. Kellas, Ashcroft, Johnson, and Needham (1973) have shown that when a person has been briefed regarding the structure of the list, and the list items are pre-organized during presentation, length of study times is related to the serial position of the items. No such relationships were reported when these two conditions were omitted. Kobosigawa and Orr (1973) reported temporal patterning of clustered recall among kindergarten children after three learning trials in which the items were presented simultaneously in their categorical groupings, but not when the items were presented randomly.

This paper presents data from two studies which examined the relationship of temporal measures of study and retrieval behavior to the use of the clustering strategy among children of different ages, sex, race, and socioeconomic backgrounds when the factor of list organization was varied. Two lists were presented--one with few categories but many items per category and a second one with many categories but few items per category. The hypothesis was that the first highly redundant list would facilitate clustering and recall more than the second list. Additionally, two hypotheses were tested

which related to temporal factors. In the first study, study time patterns were hypothesized to be related to clustering and recall. More specifically, the children would expend more time studying items later recalled and clustered, reflecting reorganization during acquisition.

STUDY 1

Method

Subjects

One hundred twenty-eight children represented in equal numbers from the second, third, fourth, and fifth grades of a white, middle-class suburban school participated in the study. There was an equal number of males and females in each grade. All of the children were judged by their teachers of be of average or above average intelligence and were performing at or above grade level.

Materials

The stimuli were 36 black and white cardboard-mounted pictures of common objects, which were instances of high frequency conceptual categories (Battig & Montague, 1969). From the 36 items, two 18-item lists were constructed. List A consisted of 3 categories with 6 items per category and List B consisted of 6 categories with 3 items per category. The categories represented in the two lists included clothing, musical instruments, animals, parts of the human body, fruit, furniture, tools, eating utensils and vehicles. Six random order presentations of each list were developed.

Procedure

Children were tested individually in a quiet separate room for approximately twenty minutes. Half of the children in each grade were randomly assigned to one of two list conditions: List A (3 categories, 6 items) or List B (6 categories, 3 items). Each child received six study/test trials on either List A or List B, depending on the condition to which he or she was assigned. The order of stimulus presentation was varied across the six trials. During the study phase of each trial, the children controlled the rate at which they studied each stimulus item. When the child finished studying each picture, he or she was instructed to drop it into a box. The examiner silently recorded an electronic tone on an audio tape by pushing a button every time the child selected the next stimulus picture. A second audio tape recorded the entire recall session with each child.

The audio tape of the study times was read by a digital interval timer. A MFE 5-line digital printer printed out the intervals of stimulus exposure (study times).

Children's clustering was calculated by the use of the _X_ measure. This measure has been found to be a more sensitive index than chance clustering in that in utilizing the individual's output as the basis for the estimate of clustering, it also considers the categorical structure of the list to be learned. (Stein, Crandall, & Budoff, Note 1).

The critical elements in the assessment of clustering are found in the following equation:

$$X = \frac{\Sigma L \ln L - E_{CQ}(n)}{\sigma_{CQ}(n)}$$

where: n = number of items recalled

L = run lengths of recalled sequence

C = number of categories in stimulus list

Q = number of elements per category in stimulus list

E = expected number of runs given C and Q in the stimulus list and n recalled by subject

$\sigma_{CQ}(n)$ = standard deviation of E

The basal (mean) value and standard deviation is set at 0 and 1 respectively. A person's score represents the degree to which he or she reorganizes the items into conceptual groups above chance level. A more detailed explanation and a table for calculating $\underline{X}$ can be found in Crandall (1975, see Note 2).

In addition to $\underline{X}$ and number of items recalled, study time was introduced as a third dependent variable. The following study time measures were calculated: (a) mean study time for items not later recalled, (b) mean study time for items later recalled in clusters, and (c) mean study time for items later recalled not in clusters. These measures account for all possible parts of the list as presented to

the subject.

Results

Four-way analyses of variance were performed on the children's correct recall, clustering, and study times. The between-subjects factors were Grade (2, 3, 4, 5), Sex (male and female), and List (A and B); the within-subjects repeated factor was Trial (1 through 6).

The analysis of children's recall and clustering showed that both recall and clustering increased significantly across grade (for amount recalled, F (3, 112) = 18.129, p <.001; for clustering, F (3, 112) = 6.965, p <.001). A significant List effect for clustering revealed that it was significantly higher for List B (six categories, three items) than for List A (three categories, six items): F (1, 112) = 17,881, p <.001. More clustering occurred when the list contained more categories with less category repetition than when it consisted of fewer, but highly redundant categories. Both clustering and amount recalled increased across trials within the experimental session (for clustering F (5, 560) = 24.502, p <.001; for amount recalled F (5, 560) = 149.64, p <.007). No sex effects were obtained on either measure. In addition to the main effects, there were two two-way interactions observed in the analysis of clustering. Mean comparisons for the List X Grade interaction (F (3, 112) = 3.386, p <.021) revealed that for second graders the lists were almost equivalent

in terms of the clustering they elicited. By contrast, fifth graders clustered more on the list with more categories and fewer items within each category. The Grade X Trials interaction (F (15, 560) = 2.796, p <.001) indicated that older subjects increased their use of the clustering strategy more as they progressed into the task than did the younger children.

Only the main effect of Trials was significant for the three study time measures. Study time always decreased across trials for all items whether they were recalled or not, or recalled in clusters or not. None of the other factors, nor any of the interactions, were significant. Patterns of mean study time were the same across all factors and there were no significant differences between any of the dependent variables themselves. For example, study times were nearly identical whether the items were later recalled or not.

Discussion

The results of the study indicate that the use of the clustering strategy increased with age and that older children were more apt to detect the categorical structure of the list and use it as an aid to recall when many conceptual categories with few category repetitions were embedded in the list. This was contrary to what we expected and will be discussed further below.

Analysis of study time did not systematically indicate the use of a clustering strategy in free recall. The analyses

indicated there were no differences in study times for conceptually different groups of items (those recalled, those clustered, and those recalled but not clustered). If, by extension from the work of Belmont and Butterfield (1969), with a serial learning task, one hypothesized that the time spent studying an item is systematically related to whether that item is recalled or whether it is recalled in a cluster were true, then the mean study time for these groups of items should have been significantly different from each other. But the children did not look at items recalled or clustered for any longer or any shorter period of time than they looked at items not recalled or not clustered.

One may conclude from these results either that clustering is unrelated to study time and therefore a chance phenomenon and not a strategy, or that reorganization of items into clusters at acquisition occurs over such short time intervals that it is not evident on these time measures since it may occur embedded within the person's personal rhythm on the task. Or it may be that the reorganization of the items into subsets does not occur during acquisition or the study phase, but at retrieval, during recall. A second study examined whether temporal factors during retrieval were related to clustering and recall.

STUDY 2

A major issue in the study of cognitive strategies concerns the time at which the organizational activity occurs within the recall process. Shuell noted (1969) that the organization which is observed during recall could occur either at the time of input or at the time of retrieval. Shuell concluded from his research that "encoding or organization must occur at the time of presentation to be effective" (1969, p. 371). Frank (Note 3), who presented the instructions to cluster at acquisition and retrieval to different subjects to determine when the clustering activity occurred, produced inconclusive findings. Since there was no evidence that the clustering activity occurs during the study phase, when one utilized study time measures, this second study investigated whether there was evidence of this activity during recall.

Specifically, the study was designed to test the hypothesis that time spent retrieving items from storage is related to the reorganization of those items recalled. It was hypothesized that if clustering occurs during retrieval, time spent on items recalled in clusters should be significantly shorter than time expended recalling sequences of unrelated words. As a corollary of this hypothesis, it follows that if recall times reflect a cognitive activity (strategies used to organized recall), the relationship between time and performance should be developmentally constant and unaffected by the organizational nature of the information, i.e., such factors as list organization.

The findings of Study 1 relating to X, the measure of clustering, and amount recalled among black and white students from a low SES community was also examined.

Method

Subjects

The subjects consisted of 112 students represented in equal numbers from the second, third, fourth, and fifth grades of urban schools located in low income neighborhoods. The overall distribution of male and female students (58 and 54, respectively) and black and white students (57 and 55, respectively) reflected the distribution in each of the four grades. All students were judged by their teachers to be of average or above average intelligence and were performing at or above grade level.

Materials

Same as Study 1.

Procedure

The procedure was the same as described in Study 1 except that inter-item retrieval times were recorded instead of stimulus exposure study times. To obtain retrieval times, the examiner silently recorded an electronic marker on an audio tape as the child said each word. As before, these tapes were read by a digital interval timer and a MFE 5-line digital printer printed the inter-item recall times. The entire session was tape recorded on a second tape.

To determine the temporal properties of recall, three

types of inter-item intervals were derived:

1. a within-cluster interval which represented the amount of time between the offset and onset of two words successively recalled from the same conceptual category,

2. a between-cluster interval which represented the amount of time between the offset and onset of two words successively recalled from different conceptual categories,

3. the interval prior to the first word recalled in a cluster, which represented the amount of time between the offset and onset of two words successively recalled from different categories but where the second word starts a cluster.

Three mean times were calculated for each child by averaging all instances of each interval type produced in all six trials.

Results

Four-way analyses of variance were performed on children's correct recall, clustering, and retrieval time. The between- and within-subject factors were the same as Study 1 except that a sex factor was dropped and replaced with a race factor.

The analysis of variance of low SES children's recall showed, as expected, a significant main effect for Grade (F (3, 94) = 8.71, p <.001). Correct recall increased from grade 2 to grade 5 (M = 9.51, 10.44, 11.29, and 12.03, respectively). The main effect for Trials (F (5, 470) = 67.84, p <.001)

indicated that children increased their recall across trials. A significant List X Type X Trials interaction (F (5, 470) = 3.22, p <.01) showed that children recalled less on List A (six categories, three items) than on List B (three categories, six items) on Trial 1, but by Trial 6, the reverse occurred; that is, children reached a higher level of correct recall on List B than on List A (see Table 1).

Insert Table 1 about here

The same four-way analysis of variance of the clustering X score indicated the expected main effects for Grade (F (3, 94) = 6.85, p <.001) and Trials (F (5, 470) = 15.73, p <.001). Children's clustering increased across grades (mean for Grade 2 = 1.42, mean for Grade 5 = 2.68) and from the first to the last trial. There was also a main effect for List Type (F (1, 94) = 5.82, p <.02) which indicated that children clustered more on List B (six categories, three items) than on List A (three categories, six items) (M = 2.21 and 1.73, respectively). There were no significant race effects for clustering or recall. These findings with children from low SES schools were similar to those reported for suburban middle-class children in Study 1.

Temporal patterns of retrieval were analyzed by a similar analysis of variance in which retrieval time factor (3) was substituted for the Trials factor. The main effect for Grade (F (3, 94) = 3.12, p <.03) indicated that children

Table 1

Mean Correct Recall on List A and List B for Trials 1 to 6

	Trial					
List type	1	2	3	4	5	6
List A	8.62	9.80	11.19	11.77	11.34	11.87
List B	7.66	10.15	11.32	11.42	11.82	12.79

Note. List A had 3 categories, 6 items in each; List B had 6 categories, 3 items in each.

in grade 5 retrieved words at a faster pace (M = 2.72 seconds) than students in grade 2 (M = 3.63 seconds), regardless of how they were recalled. Clustered words were recalled more rapidly in temporal bursts (M = 2.26 seconds) than words recalled in isolation (M = 3.9 seconds) and than the initial word of a clustered run (M = 3.2 seconds) (main effect for retrieval time category, F (2, 188) = 30.86, p <.001). These temporal patterns were similar for black and white students regardless of grade.

Discussion

The black and white students from a low SES, urban community exhibited the same grade, trial, and list organization effects on recall and clustering that were evidenced by middle class students.

In this study it was hypothesized that the patterning of retrieval time would directly reflect the cognitive process of clustering. The test of this hypothesis would be its stability across factors such as Grade and List Condition. If either a second grader or a fifth grader uses clustering as a strategy, the relative time representation of that strategy should be equivalent. Likewise, clustering occurring at any point in the experimental session and on any set of materials should reflect the same time pattern. Except for the fact that older children generally recalled at a faster rate than younger children, this hypothesis was supported.

The data collected from this study permit a further test of the usefulness of response times as an index of strategy use.

A comparison of the means for clustered and nonclustered intervals revealed an overwhelming pattern of consistency within each measure for all ages, regardless of the categorical structure of the list. In addition, clustered intervals were consistently and significantly shorter than nonclustered intervals. This finding lends further support to the notion of stability of the retrieval time measures. It provides support for the hypothesis that clustered recall temporally reflects the presence of a conceptual grouping of items. Items recalled within clusters are characterized by very short intervals between the items constituting the category, often less than 2 seconds, than across category boundaries. Pollio, Richards, and Lucas (1969) have hypothesized that the longer between category intervals between nonclustered items, often involving from 3 to 5 seconds, reflects the search for and identification of superordinate category names, and, perhaps, the failure in this search. By contrast, the consistently intermediary length of intervals preceding first words in clusters may reflect the successful generation of the category name which then acts as mediator for the rapid flow of category members that follows. This possibility needs further research. Consistent time patterns like those found in this study provide support for utilizing temporal patterns associated with strategy usage to understand more fully the processes of strategy application.

The hypothesis about the characteristics of the list

were not supported. Contrary to expectation, clustering and recall were higher on the many-category, few item list than the few category, many item list. This latter list may have been insufficiently differentiated for these children, who had to spontaneously impose an organization on the list. In fact, many children created new categories on this list, grouping subsets of items from within a category. The differences among the items on the six category list may have made the saliency of the category grouping as a conceptual peg for recall more evident. One interesting finding is that the low SES children's recall performance on the two lists changed over the course of the six trials. The three category list evoked higher recall scores in the early trials, the six category list evoked higher recall scores on the later trials. Clustering performance, however, was not affected in this manner.

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Footnote

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